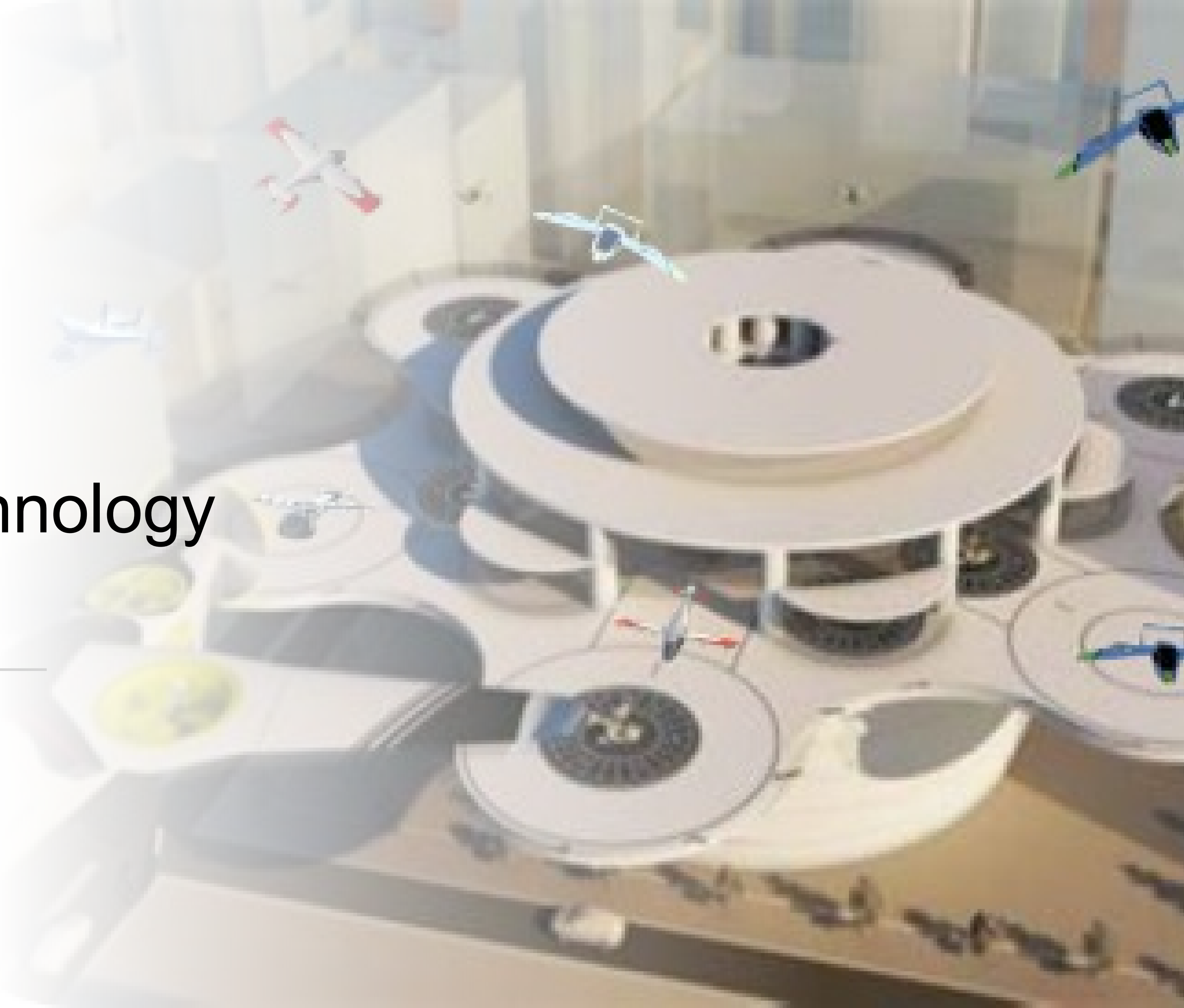
INTERNATIONAL FORUM FOR AVIATION RESEARCH

IFAR UAM Infrastructure Technology

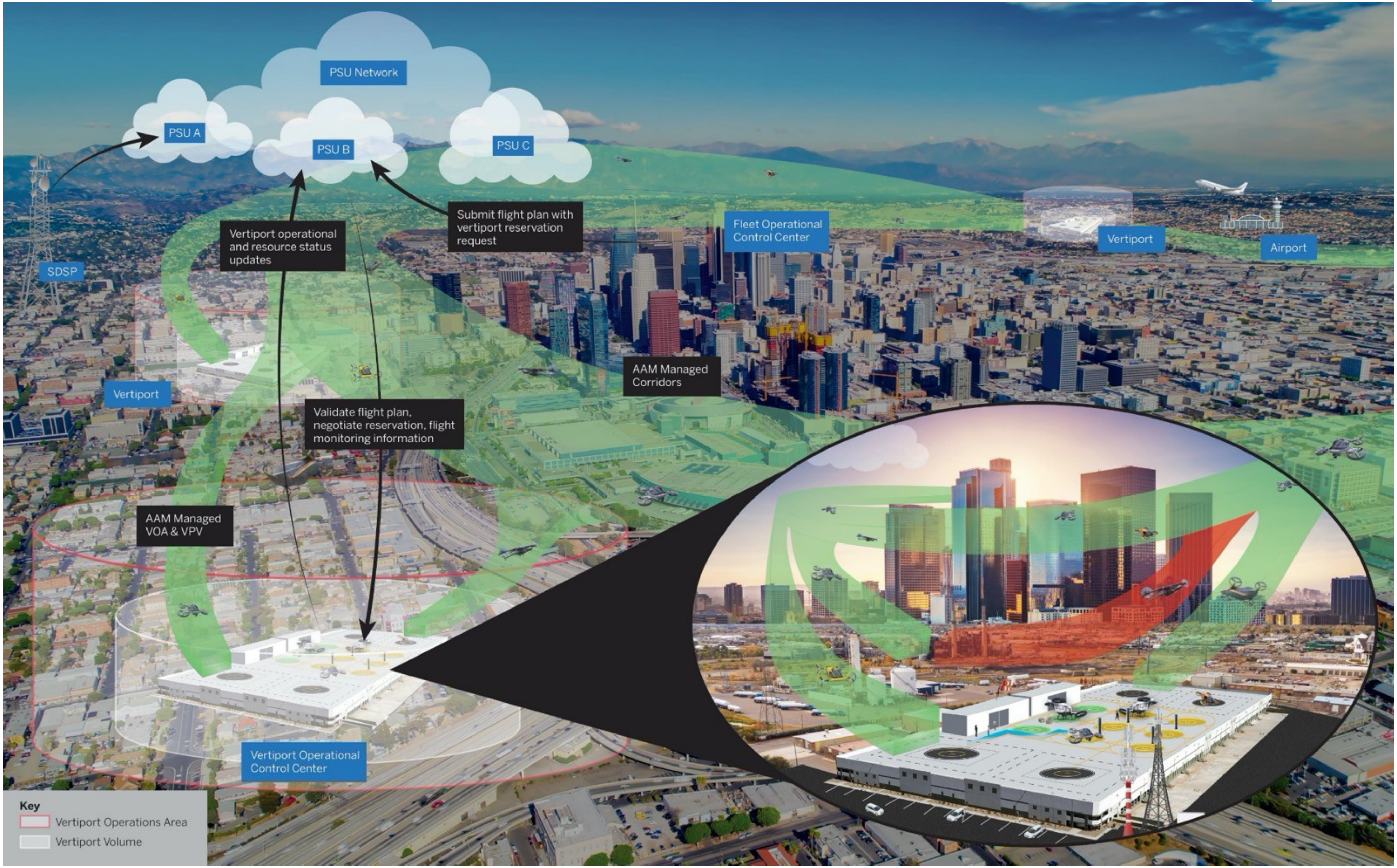


Dr. Marcus Johnson, NASA

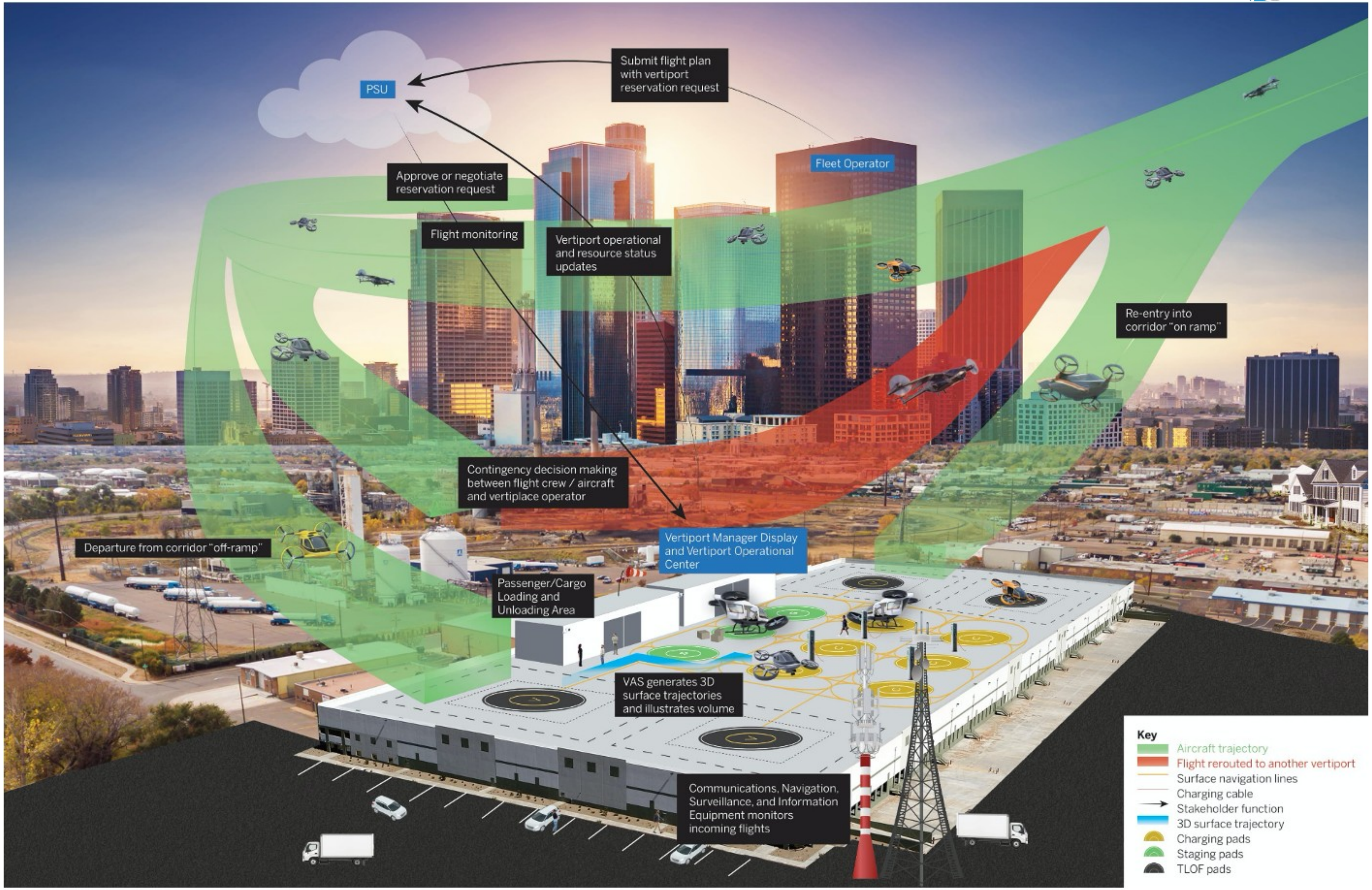
Agenda

- NASA Vision and High Density Vertiplex (HDV) Research
- IFAR Discussion Status

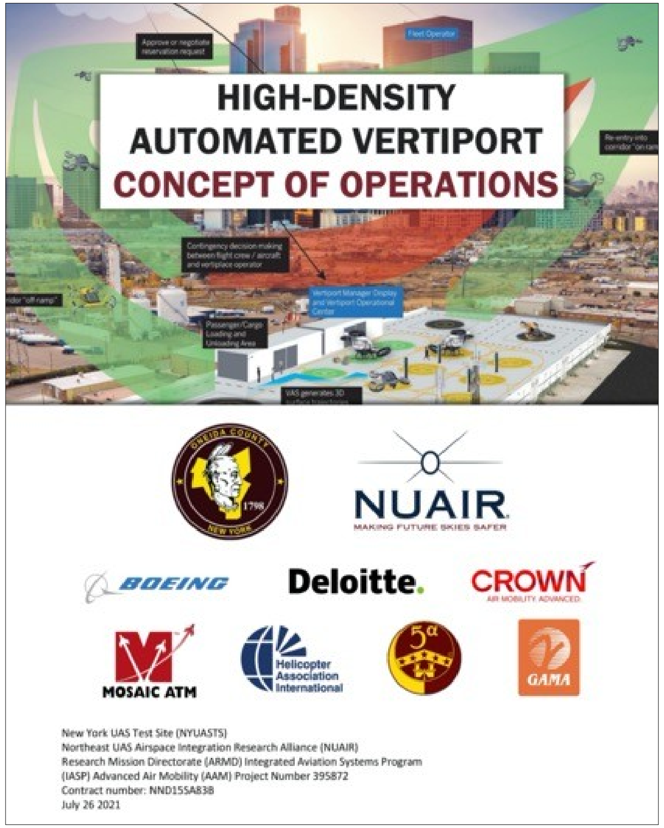
NASA's Concept for High-Density Automated Vertiport Operations



NASA's Concept for High-Density Automated Vertiport Operations



NASA’s Concept for High-Density Automated Vertiport Operations



https://ntrs.nasa.gov/citations/20210016168

https://ntrs.nasa.gov/citations/20210019083

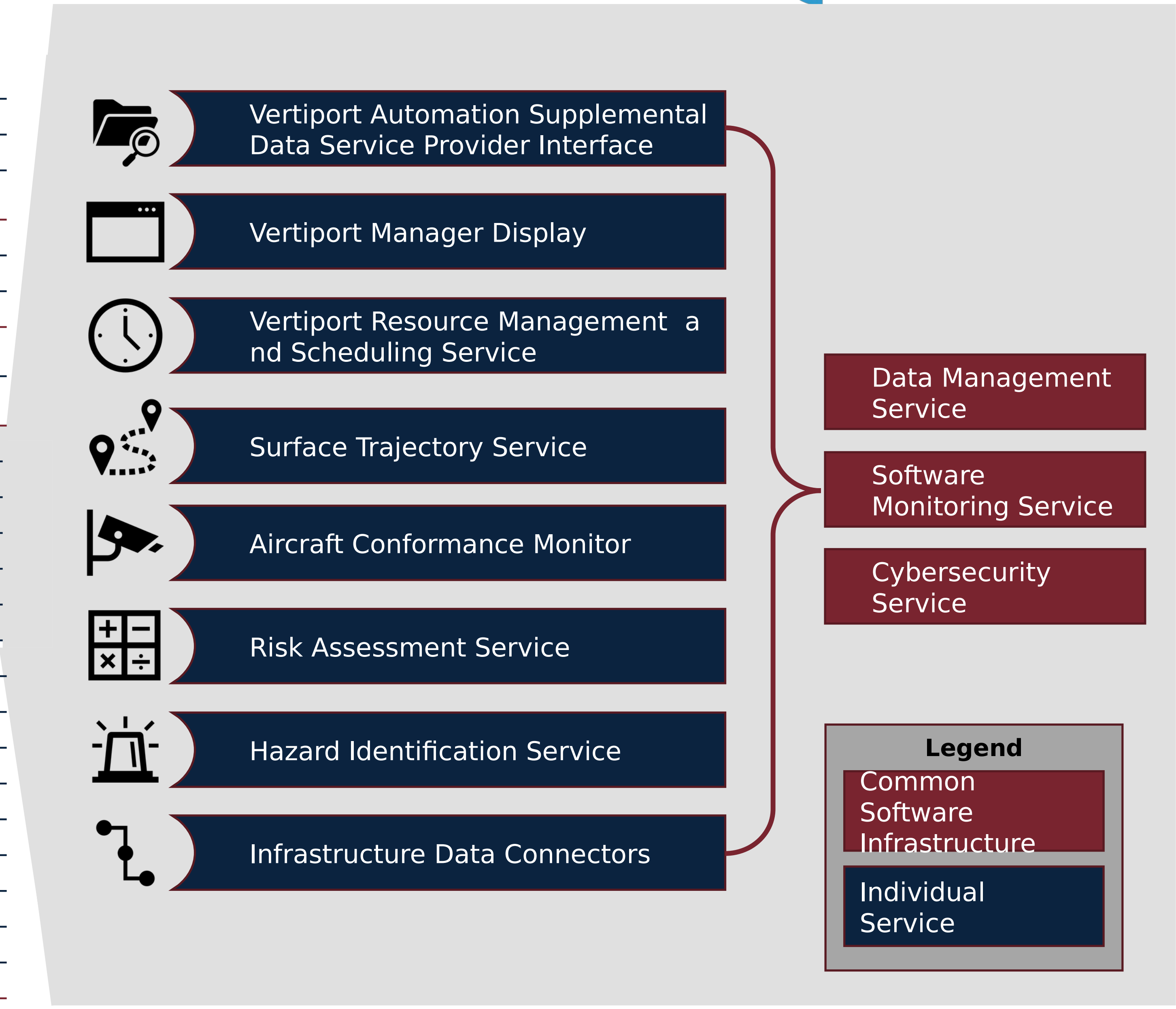
- Developed relevant requirements, considerations, barriers, and enabling technologies.
- Inform operationalization of vertiports and maturation of vertiport automation technologies at UML-4.

- Developed a vertiport automation architecture, requirements, and test methods for services to support CONOPS.
- Modeled Vertiport Automation System in MBSE .

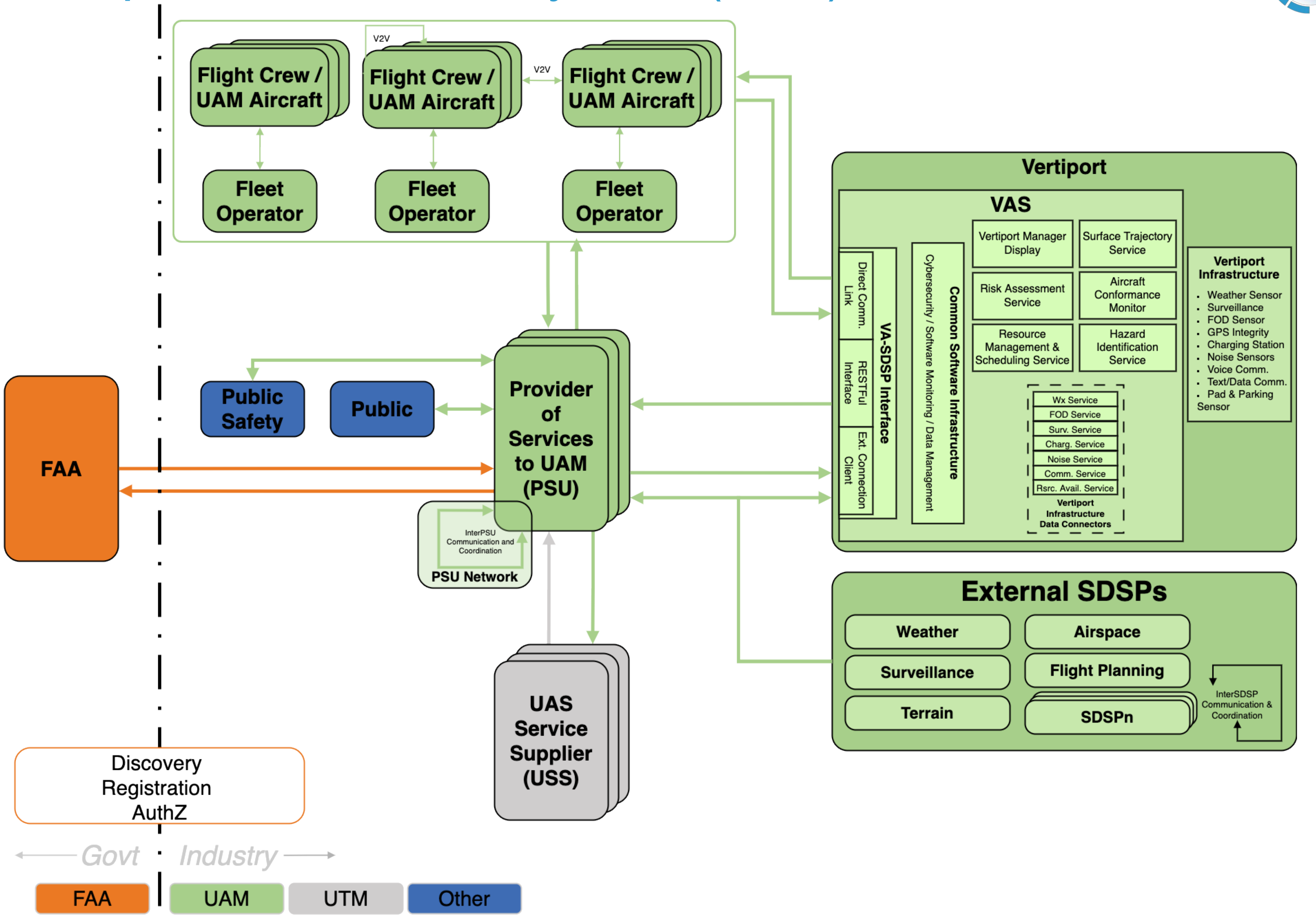
CONOPS Organization

ConOps Organization Based on IEEE Standard 1362-1998.

1. Introduction	Purpose and Scope
	Assumptions and Constraints
	UML Mapping
	Operational Stakeholder Descriptions
2. Current State	Description of Current State
	AAM Vertiport State-of-the-Art Assessment
	Vertiport Challenges and Barriers
3. Desired Changes	Rationale for Changes
	Description of Desired Changes
4. Future State Concept of Operations	Description of the Proposed System
	Operational Environment
	Operational Stakeholders
	Vertiport Automation System Services
	Vertiport Automation System Relationships
	Configuration Decisions
5. Operational Scenarios	Base Nominal Scenarios
	Off-Nominal Scenarios
	Resource Allocation
6. Summary of Impacts	Operational Impacts
	Organizational Impacts
	Impacts During Development
7. Analysis of Proposed System	Summary of Improvements
	Disadvantages and Limitations
	Alternatives and Tradeoffs Considered
	Path Forward



NASA Vertiport Automation System (VAS) Architecture



NASA High Density Vertiplex Research Overview

CY2021	CY2022	CY2023	CY2024	CY2025	CY2026
Advanced Onboard Automation	Scalable Autonomous Operations	Vertiplex Operations		IAS-2	NC-3

Key Deliverables

Automated Aircraft

Small UAS

X 3

Automated Landing

Small UAS

X 5

Missed Approach

Small UAS

X 7

Contingency Decision Making

AAM eVTOL

Terminal UAM Environment Reference Architecture

Operations

Simulation and Multi-Aircraft VLOS Flight Test

Simulation and Limited BVLOS

Simulation and Expanded BVLOS Operations

Operational Environment

High Density Vertiport CONOPS

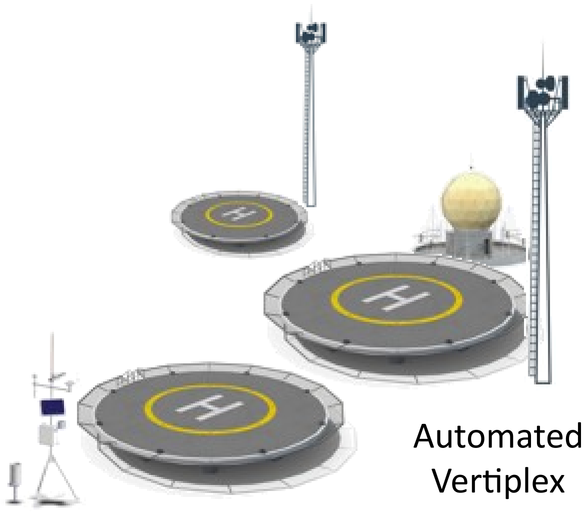
Vertiport Use Cases

BVLOS Safety Case

Infrastructure

Vertiport Terminal Procedures Design

Instrumented and Connected Vertiport



Automated Vertiplex

Vertiport Automation System Architecture & Requirements [MBSE]

IFAR UAM Infrastructure Technology Status

Assumptions – Vertiport Evolution

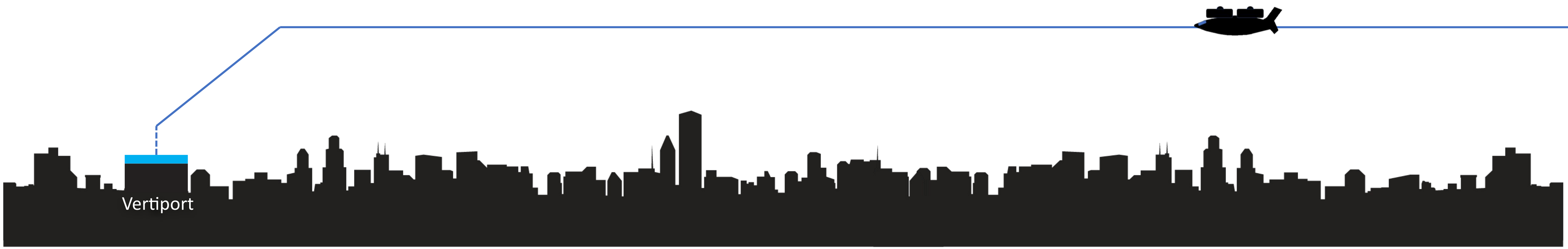
- **Initial vertiports will likely be established using current infrastructure (on-airport, off-airport, heliport) in the near-term and new infrastructure in the far term (e.g. greenfield, brownfield).**

Current Infrastructure

Urban Area Vertiports

Assumptions – Aircraft and Operations Assumptions

- **Near Term (2025)**
  - Operations will be VFR piloted operations
  - Low Operational Tempo
  - ATC Interactions
- **Far Term (2035+)**
  - Operations will be IFR and VFR, including remotely piloted and autonomous
  - High Operational Tempo
  - Digitalized Air Traffic Management



Assumptions – Representative VTOL Aircraft

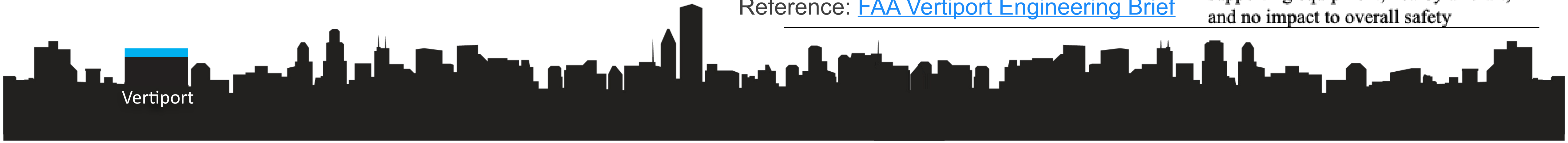
- Limits
  - Passenger Carrying (4-5)
  - MTOW = 7,000 lbs (3,175 kg) or less
  - Aircraft Length = 50 ft (15.2 m)
  - Aircraft width = 50 ft (15.2m)
  - Power Source = Electric / Hybrid
  - Pilot onboard near term, (semi-) autonomous far term
  - No taxing (initially), surface movements / parking / taxing* (long term)
  - 1 FATO near term, at least (2+) FATOs far-term
- Needs more discussion
  - Icing / ground handling
  - Aircraft Equipage / Autonomy

Design Characteristics	Criteria
Propulsion	Electric battery driven utilizing distributed electric propulsion
Propulsive units	2 or more
Battery packs	2 or more
Maximum takeoff weight (MTOW)	7,000 pounds (3,175 kg) or less
Aircraft length	50 feet (15.2 m) or less
Aircraft width	50 feet (15.2 m) or less

Operating Conditions	Criteria
Operation location	Land-based (ground or elevated) – no amphibian or float operations
Pilot	On board
Flight conditions	VFR

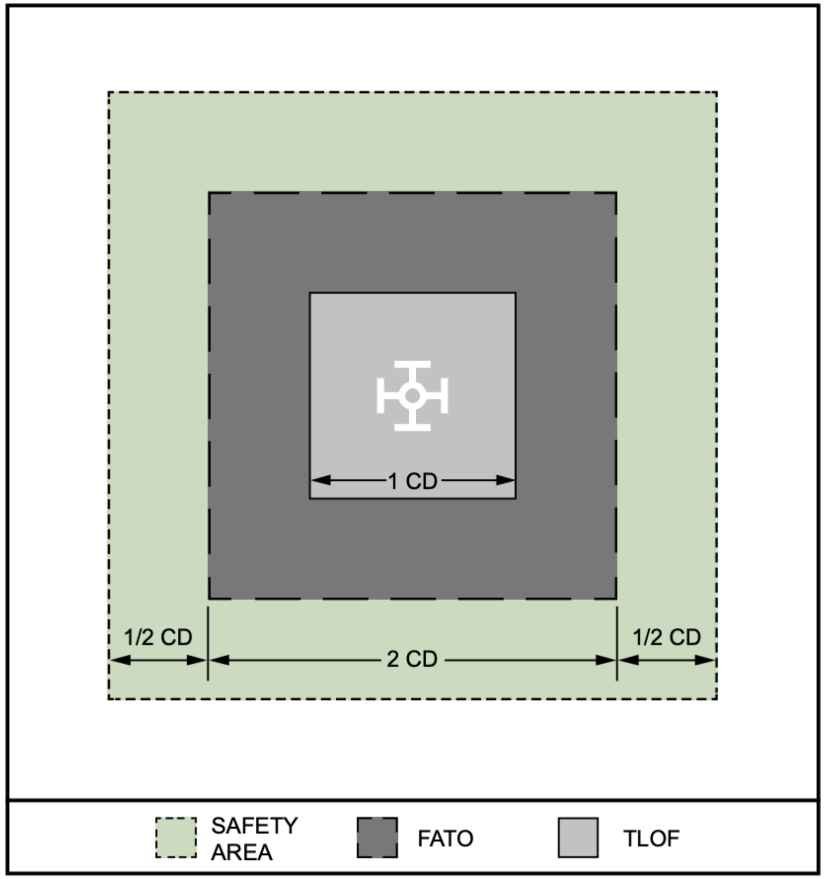
Performance	Criteria
Hover	HOGE in normal operations
Takeoff	Vertical
Landing	Vertical
Downwash/Outwash	Must be considered in TLOF/FATO sizing and ingress/egress areas to ensure no endangerment to people/property in the vicinity, and no impact to safety critical navigational aids and surfaces, supporting equipment, nearby aircraft, and no impact to overall safety

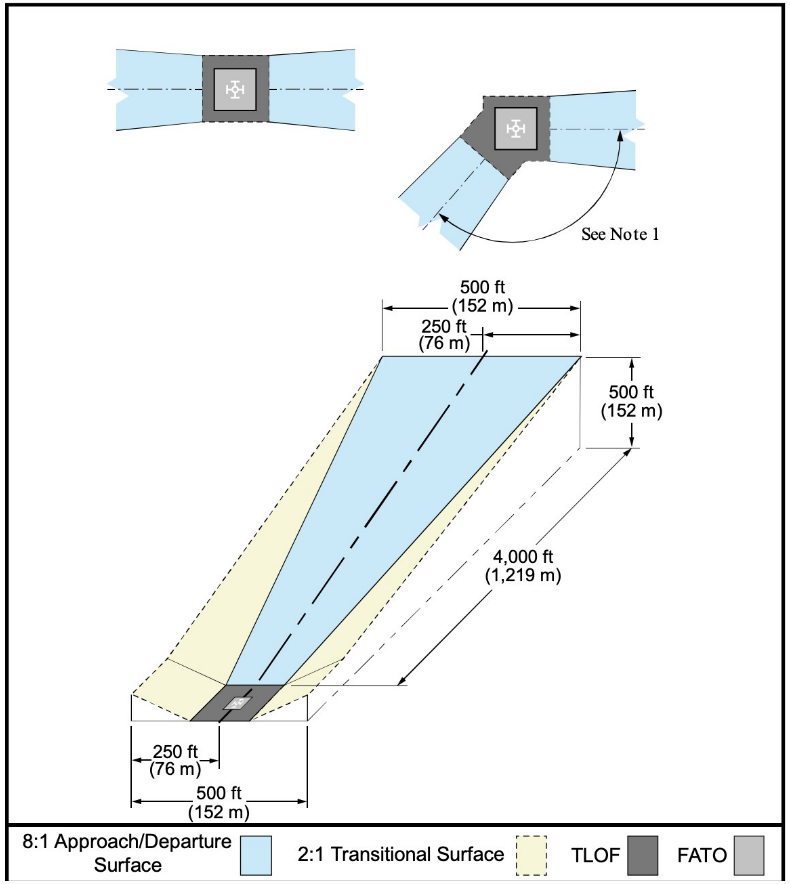
Reference: FAA Vertiport Engineering Brief



Assumptions – Vertiport Design

- Vertiport design criteria guidance will be specified by each national aviation authority
- Vertiport design should include a TLOF, FATO, Safety Area and Arrival/Departure surfaces
- Considerations for glide path angles, climb gradients on arrival departure consistent with more dynamic aircraft performance





Reference: [FAA Vertiport Engineering Brief]

Areas of Agreement

- Not all solutions employed in today's heliports and airports will be suitable for vertiports
  - Many of the technologies are relevant, however need to be optimized for AAM aircraft and operation if deployed at a vertiport
  - The scale or tempo of operations may make some technology unsuitable
  - Increase in operational tempo will drive the need for more technology to support throughput and complexity.
  - Different aircraft fuel sources will have design and operational impacts (e.g. scheduling recharging)
- The technology solutions will need to evolve as the operations evolve (pilot vs remotely piloted vs. autonomous)
- In order to gain trust in the technologies, multiple pilot tests, demonstrations, and trials are needed to convince stakeholders of the value to invest and deploy in existing or new infrastructure
- Technology areas for consideration:
  - Communication / Navigation / Surveillance / Information
  - Safety Systems
  - Refueling / Recharging
  - Security
  - Handling

Recommendation Status

- Discussions ongoing on technology challenges
- Discussion ongoing on identifying where technology R&D is warranted
- Cataloging ongoing research activities to address

- Recommendations will include the assumptions, challenges, and architectures and/or technology research suggestions
  - Ongoing testing will inform functional, interface, and performance requirements

- Further discussions are need to develop a technology roadmap (from near-term to far-term).

Discussion / Questions

Recent Research Publications

- NASA AAM Vertiport Automation Trade Study
- NASA High Density Vertiport CONOPS
- NASA Vertiport Automation Software Architecture and Requirements

Terminology

- **Final approach and takeoff area (FATO):** The FATO is a defined, load-bearing area over which the aircraft completes the final phase of the approach, to a hover or a landing, and from which the aircraft initiates takeoff. (FAA Engineering Brief #105)
- **Operational tempo**: Representation of the density, frequency, and complexity of operations. Tempo evolves from a small number of low complexity operations to a high density and high rate of complex operations. (FAA Engineering Brief #105)
- **Touchdown and liftoff area (TLOF):** The TLOF is a load bearing, generally paved area centered in the FATO, on which the aircraft performs a touchdown or liftoff. (FAA Engineering Brief #105)
- **Vertiport**: An area of land or a structure, used or intended to be used, for electric, hydrogen, and hybrid VTOL landings and takeoffs and includes associated buildings and facilities. (FAA Engineering Brief #105)

VTOL – Vertical Takeoff and Landing